Technology Management Division
Schafer Corporation
Arlington, Virginia

March 2005

Genetic Algorithm-Based System Design and Photonics-Based Receiver Technologies Program SETA Support

By
Ronald Cestaro and Jack Howard

FINAL Report
August 2003 – December 2003

Sponsored by:
Defense Advanced Research Project Agency
Advanced Technology Office
Task Order Title: SETA Support for Genetic Algorithm-Based System Design and Photonics-Based Receiver Technologies
ARPA Order No. Q383
Issued by DARPA/CMO under Contract No. MDA972-01-D-0002

Schafer

April 4, 2005
LRS-05-0404
01W-37/DO 0018

Defense Advanced Research Projects Agency (DARPA)
3701 N. Fairfax Drive
Arlington, VA 22203-1714

Attention: Dr. Francis W. Patten
DARPA/ATO Program Manager

Reference: Contract No. MDA972-01-D-0002, Delivery Order No. 0018

Subject: Final Technical Report

Dear Dr. Patten:

In accordance with Article C-2, Reports and Other Deliverables, Schafer Corporation (Schafer) is pleased to submit the Final Technical Report with regard to the subject delivery order.

Questions of a technical or programmatic nature should be addressed to John J. Howard, Schafer's Program Manager at 703/516-6021. Please feel free to contact the undersigned at 978/256-2070, ext. 1252 if you have any contractual or administrative questions.

Thank you.

Sincerely,

SCHAFER CORPORATION

Susan L. Ronzio
Sr. Contract Administrator

Enclosure

cc: DARPA/COR
Mr. Patrick Bailey

DARPA/ASBD Library

Defense Technical Information Center
ATTN: DTIC-BCS
8725 John J. Kingman Road
Suite 0944
Fort Belvoir, VA 22060-0944

DCMA – one copy of cover letter and cover report
495 Summer Street
Boston, MA 02210-2138
Mail Code: D5C

Abstract

This is the final report for the Schafer Corporation Genetic Algorithm-Based System Design and Photonics-Based Receiver Technologies Program support under delivery order No. 0018 covering the period of August 2003 through December 2003.

This report covers the work accomplished by *Team Schafer* (Schafer Corporation and Booz Allen Hamilton). *Team Schafer* supported DARPA with programmatic, technical, and financial assistance support.

Table of Contents

1.0 Introduction

The Defense Advanced Research Projects Agency (DARPA) programs often involve the application of emerging techniques of analysis and design to mature technology to provide revolutions in system capabilities. The two program areas described herein fit within this general framework. The first task described is the application of genetic algorithms to design electronics system solutions. The second is the application of photonics component technologies with other high-performance electronics components to produce receivers with heretofore unattainable performance in spur-free dynamic range, when referenced to bandwidth.

1.1 Genetic-Based System Design

In analysis tasks, algorithms are routinely used to perform calculations or manipulations on functions or values that form the solution of a problem; such as the currents on an antenna/optics based front-end/receiver or the values of basis functions in a mathematical transformation. In these examples, it is clear how to define success in terms of the fit of the solution to a physical or mathematical principle or law such as conservation of energy or mean squared error. In these tasks, there is often little need for creative solutions as "brute force" calculation is often adequate.

In complex design tasks, however, the relevant solution space can be extremely large and human intuition is often inadequate to propose design paradigms that are maximally efficient. Usually, researchers start with modifications to existing designs or to introducing new materials or subsystems into conventional designs to produce generational improvements to systems. To produce groundbreaking results, researchers are starting to turn to new paradigms of design and analysis such as genetic algorithms. Although genetic algorithms often produce unconventional designs, they will be efficient based on rules that the system developer defines and will generally fall outside of the typical suite of solutions.

One can conceive of many ways in which such system design may be carried out, but this task will look at several such examples and provide guidance for its application to systems relevant to the ATO mission.

1.2 Photonics-Based Receiver Technologies

Photonics component technologies have been pursued for a number of years in the development of all-optical systems and for their linearity and digitization advantages over standard electronic receivers. This effort was intended to use these component technologies to exploit their advantages at the system level. A photonics-based receiver could be the key to performing a wide variety of Radio Frequency (RF) reception operations in strong RF Interference (RFI) environments. Intelligence, Surveillance, and Reconnaissance (ISR) is a key capability that will become increasingly important as our military transforms into a faster, lighter, and more flexible, responsive and lethal force. The types of threats

and battlefield environments that are likely to face our military in future conflicts have shifted dramatically in recent years. A high degree of situational awareness will be needed for the survival of our future warfighting systems. The ability to provide assured and effective communications, signals intelligence, and battlefield sensing and to deny these capabilities to our adversaries will be essential.

Strong RFI environments are a frequent hallmark of military operations. Powerful radars and jammers create interference that poses significant challenges in detecting and exploiting many classes of signal. A photonics based front-end receiver seeks to integrate emerging direct and wideband Optical Sampling (OS) and Optical Channelization technologies to demonstrate, at the system level, significant advances in detecting and exploiting RF signals in demanding interference environments.

2.0 Task Objectives

Team Schafer was tasked to assist the DARPA Advanced Technology Office (ATO) in achieving their objectives in their Genetic Algorithm-Based System Design and Photonics-Based Receiver Technologies efforts. It provided scientific, engineering, technical, programmatic, and administrative support for DARPA research and systems engineering efforts. The Team's administrative support consisted of that administrative support necessary to perform the technical tasks under this contract. Team members were proactively employed to interact with the contractors and program team to conduct analyses that predicted program performance capabilities and identified potential problems to obviate performance shortfalls. *Team Schafer* performed the following functions:

- Research and Development
  - Technical Research Analysis and Evaluation
  - Engineering and Technical Integration
  - Independent Technology Assessment
  - Technology Transition

- Management and Professional Support Services
  - Program Planning and Control
  - Performance Measurement
  - Facilities and Logistics Support
  - Administrative Program Support
  - Transition Plan/Schedule/Phasing
  - Coordination and Sponsoring of Program Reviews and Workshops
  - Principal Investigator Meeting and Technical Conference Planning and Support

2.1 Genetic Algorithms Task Objective

Team Schafer provided the Defense Advanced Research Projects Agency (DARPA) with support to facilitate the study of the utility of genetic algorithms in system design tasks relevant to the ATO mission. *Team Schafer:*

- Supported the study of Genetic Algorithms by identifying, researching, and analyzing potential applications of genetic algorithms in complex system design.
- Supported the development of program metrics by establishing and quantifying performance metrics for the program
- Supported the development of a Program Management & Funding Plan by developing a schedule and execution plan for the program.

2.2 Photonics-Based Technologies Task Objectives

Team Schafer provided DARPA with support to facilitate the establishment of a new photonics based front-end receiver demonstration program. *Team Schafer*:

- Supported the development of photonics-based, front-end receiver concepts. It also assisted in identifying, researching, and analyzing potential applications, concepts of operation, and military utility for a Photonics-based front-end receiver.
- Supported the development of program metrics by establishing and quantifying performance metrics for the program.
- Supported the development of a Program Management & Funding Plan by developing a schedule and execution plan for the program.

3.0 Technical Problems

Team Schafer did not encounter any technical barriers when conducting its tasking.

4.0 General Methodology

Team Schafer worked within DARPA processes and procedures in supporting the programs. Technology transfer direction was initiated by the DARPA PM and then augmented by *Team Schafer* support.

5.0 Significant Hardware Development

Team Schafer did not develop any hardware.

6.0 Special Comments

The descriptions of the DARPA support herein are applicable to the support *Team Schafer* provided to the DARPA Advanced Technology Office on Delivery Order 0018.

7.0 Implications for Further Research.

None.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, Va 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.			
1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE 3/31/2005	3. REPORT TYPE AND DATES COVERED Final - 5 August 2003 through 4 December 2003	
4. TITLE AND SUBTITLE Genetic Algorithm-Based System Design and Photonics-Based Receiver Technologies Program SETA Support			5. FUNDING NUMBERS C - MDA972-01-D-0002/0018
6. AUTHOR(S) Ronald G. Cestaro and Jack Howard			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Schafer Corporation Technology Management Division 3811 North Fairfax Drive, Suite 400 Arlington, VA 22203			8. PERFORMING ORGANIZATION REPORT NUMBERS
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Defense Advanced Research Projects Agency 3701 North Fairfax Drive Arlington, VA 22209			10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT			12b. DISTRIBUTION CODE
13. ABSTRACT (Maximum 200 words) This is the final report for the Schafer Corporation Genetic Algorithm-Based System Design and Photonics-Based Receiver Technologies Program support under delivery order No. 0018 covering the period of August 2003 through December 2003. This report covers the work accomplished by Team Schafer (Schafer Corporation and Booz Allen Hamilton). Team Schafer supported DARPA with programmatic, technical, and financial assistance support.			
14. SUBJECT TERMS			15. NUMBER OF PAGES 5
			16. PRICE CODE
17. SECURITY CLASSIFICATION Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT

NSN 7540 - 01 - 280 - 5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std. 239-18